Understanding How LEDs Work

A REEL Power ^{tm} (Renewable Energy Education Lab) Lesson

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LESSON OVERVIEW

This lesson demonstrates how LEDs or Light Emitting Diodes can be wired in series and parallel configurations with the resultant affects on voltage, current, resistance, power and energy. Students learn that LEDs of different colors also differ in their power consumption and other electrical parameters.

LEARNING OUTCOME

Students learn that LEDs are solid state electronic components, like transistors, that happen to generate light of different colors.

Students come to understand that:

1. LEDs are different than regular light bulbs since they give off light but not light and heat like regular light bulbs.

2. LEDs are different than regular light bulbs since they have polarity like a battery.

3. LEDs are different than regular light bulbs since they emit specific colors of light.

STUDENT ACTIVITIES

Students setup the equipment to wire multiple LEDs of different colors in series and parallel configurations. During the course of the lesson, students measure and record voltage, current, resistance and power with the ***Smart Meter – Data Logger*** ^{tm}**.** Students are charged with understanding how to arrange LEDs (which are polarized devices like batteries) in series and parallel configurations.

GRADE-LEVEL APPROPRIATENESS

This lesson is appropriate as an introduction to solar energy data interpretation for students in grades 8–10.

LESSON TIME

This lesson should take between 30 minutes to 45 minutes depending on discussion time about the experiment.

SAFETY

No particular safety issues are deemed present in this lesson; however, particular attention to the setup and execution of the lesson is always prudent in order to avoid unintentional mistakes and the resultant possible harm to those involved.

REQUIRED MATERIALS

Qty	Description
1	Solar Panel
1	***Smart Meter – Data Logger*** tm
1	USB cable
5	Clip leads
2	Red LEDs
2	Green LEDs

PRELIMINARY STEPS

1. Install the graphical software on the classroom computer.
2. Install a fresh 9-volt battery in the ***Smart Meter – Data Logger*** tm
3. Refer to the ***Smart Meter – Data Logger*** tm **Tutorial** for extra help.

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EQUIPMENT SETUP

1. Setup the equipment as shown in Figure 1 below. Wire the solar panel modules in series and attach them to the Input terminals of the ***Smart Meter – Data Logger*** tm.

2. Attach a single red LED to the Output terminals. Make sure that the longer lead goes to the positive (+) red terminal and the shorter lead goes to the negative (-) black terminal.

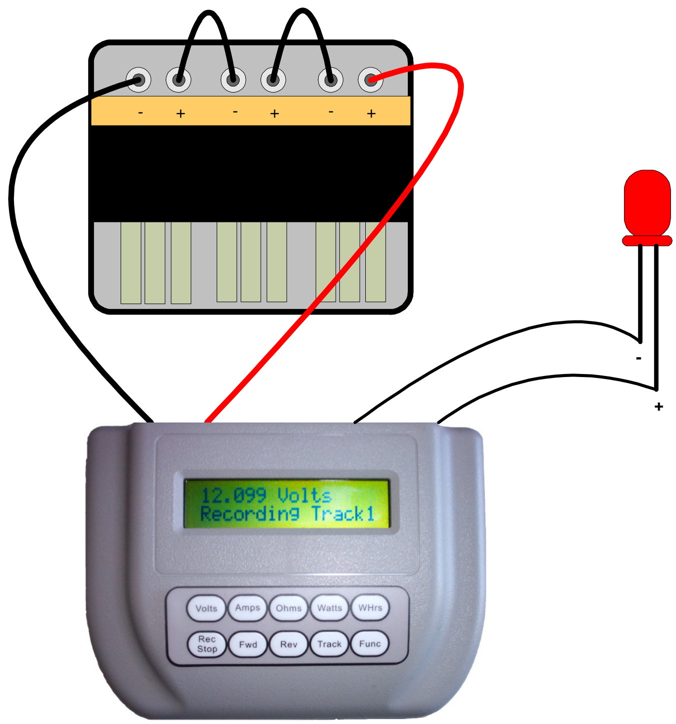

Figure 1 – Initial Equipment Setup with Single Red LED

TEACHING THE LESSON

1. Orient the solar panel so that it receives the maximum amount of light from either the sun or a bright artificial light. There should be sufficient light to illuminate the red LED.

2. On the ***Smart Meter – Data Logger*** tm push the **Volts**, **Amps**, **Ohms** and **Watts** keys and record the respective readings.

3. Replace the red LED with a green LED and repeat step 2.

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4. Create a table like the one below to compare the readings.

Single	**Volts**	**Amps**	**Ohms**	**Watts**
Red LED	2.020	0.022	91.81	0.044
Green LED	2.305	0.022	104.77	0.050

Table 1 – Red LED Compared with Green LED

5. Setup the equipment as in Figure 2 with two red LEDs in series.

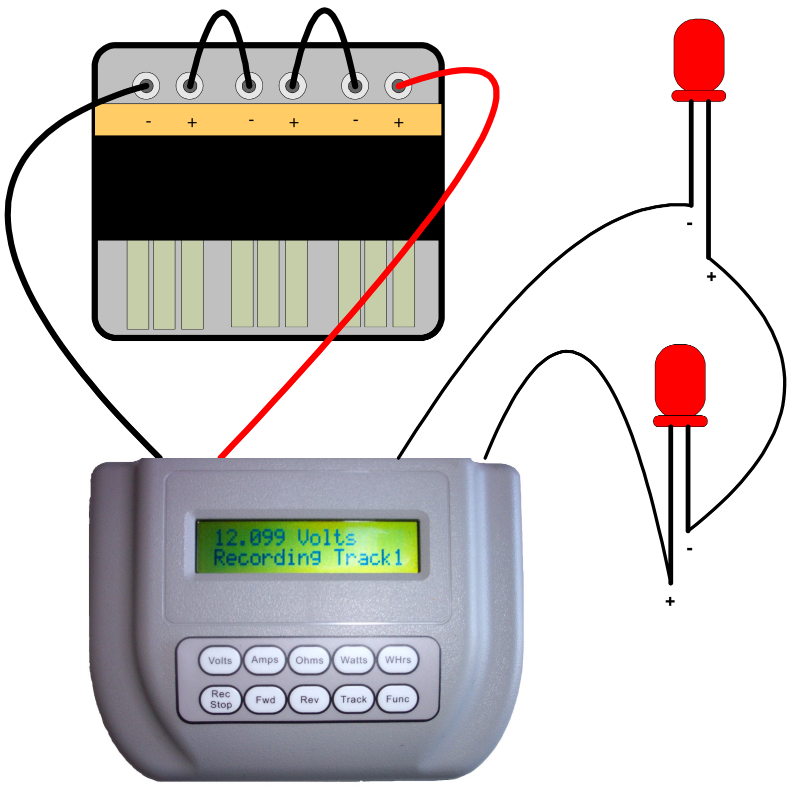

Figure 2 – Equipment Setup with Two Red LEDs in Series

6. On the ***Smart Meter – Data Logger*** ^{tm} push the **Volts**, **Amps**, **Ohms** and **Watts** keys and record the respective readings.

7. Replace the red LEDs with a green LEDs and repeat step 6.

8. Create a table like the one below to compare the readings.

2 in Series	**Volts**	**Amps**	**Ohms**	**Watts**
Red LEDs	3.791	0.013	291.61	0.049
Green LEDs	4.069	0.007	581.28	0.028

Table 2 – Red LEDs in Series Compared with Green LEDs in Series

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9. Setup the equipment as in Figure 3 with two red LEDs in parallel.

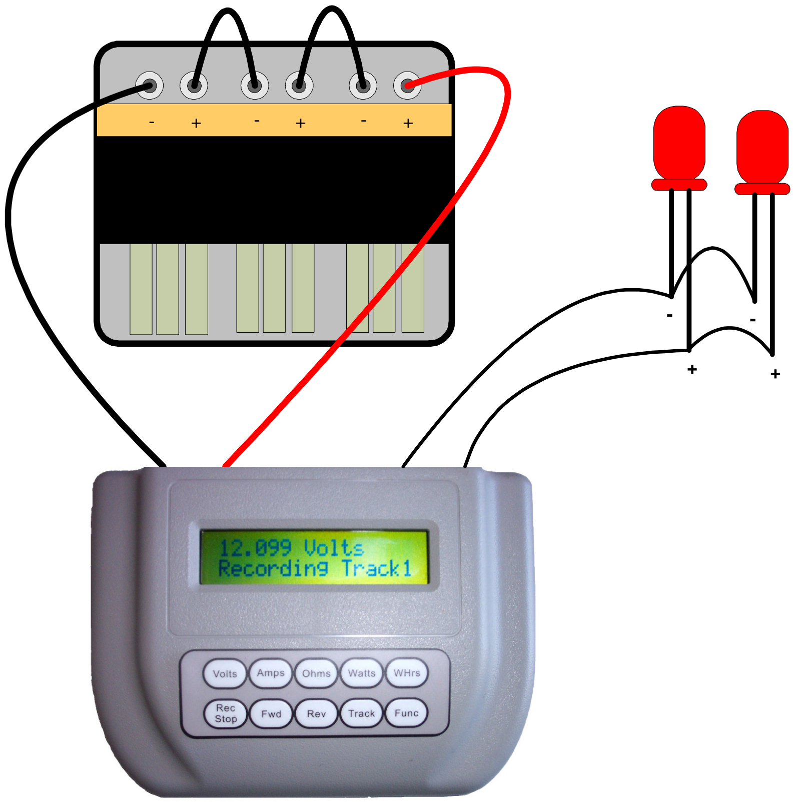

Figure 3 – Equipment Setup with Two Red LEDs in Parallel

10. On the ***Smart Meter – Data Logger*** ***tm*** push the **Volts**, **Amps**, **Ohms** and **Watts** keys and record the respective readings.

11. Replace the red LEDs with a green LEDs and repeat step 10.

12. Create a table like the one below to compare the readings.

2 in Parallel	**Volts**	**Amps**	**Ohms**	**Watts**
Red LEDs	1.840	0.023	80.00	0.042
Green LEDs	2.118	0.023	92.08	0.048

Table 3 – Red LEDs in Parallel Compared with Green LEDs in Parallel

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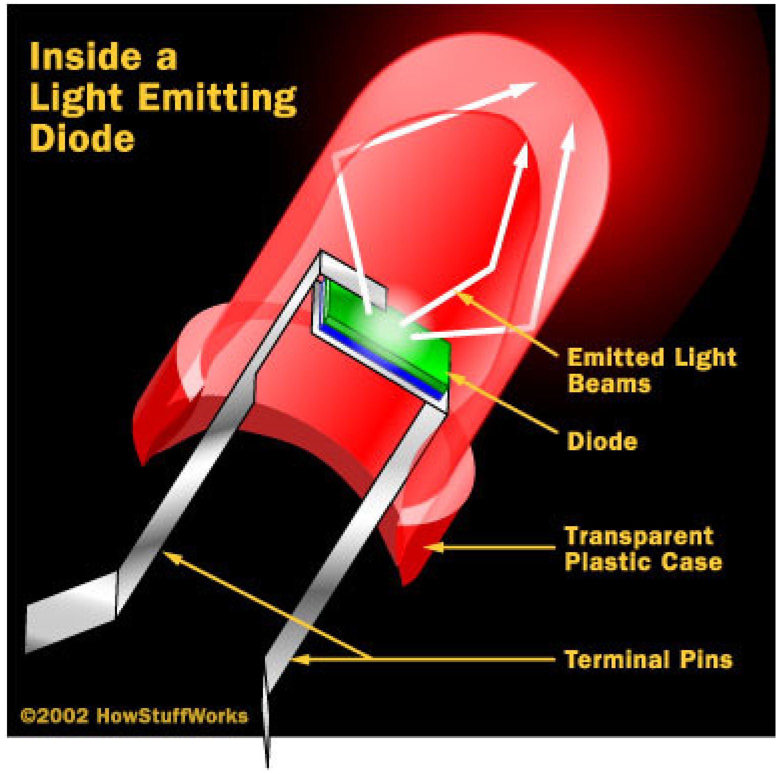
DISCUSSING THE LEARNING OUTCOME



Before going into a discussion of the gathered data, first inform the students as to the inner workings of an LED. Begin by saying that a light-emitting diode (LED) is a semiconductor device that creates light using solid-state electronics. A diode, which is like a one-way electronic valve, is composed of a layer of electron-rich material separated by a layer of electron deficient material which forms a junction. When power is applied to this junction it excites the electrons in the electron rich material leading to photon emission and the creation of light. Depending on "the chemical composition of the semiconductor layers", the color of light emission will vary within the electromagnetic spectrum. Hence, this is how we get red and green LEDs as well as other LED colors including clear white. LED image courtesy of HowStuffWorks.com

Next, tell them that LEDs have several advantages over conventional incandescent lamps. For one thing, they don't have a filament that will burn out, so they last much longer. Additionally, their small plastic bulb makes them a lot more durable. They also fit more easily into modern electronic circuits.

But the main advantage is **efficiency**. In conventional incandescent bulbs, the light-production process involves generating a lot of heat (the filament must be warmed). This is completely wasted energy, unless you're using the lamp as a heater, because a huge portion of the available electricity isn't going toward producing visible light. LEDs generate very little heat, relatively speaking. A much higher percentage of the electrical power is going directly to generating light, which cuts down on the electricity demands considerably. Blub image courtesy NASA.

Until recently LEDs were too expensive to use for most lighting applications because they're built around advanced semiconductor material. However, the price of semiconductor devices has plummeted over the past decade making LEDs a more cost-effective lighting option for a wide range of situations. You can find LEDs on car tail lights as well as on traffic lights. You can even buy an LED flashlight that will last a lifetime and never wear out. While LEDs may be more expensive than incandescent lights up front, their lower cost in the long run can make them a better buy. In the future, they will play an even bigger role in the world of technology. LED flashlight image courtesy Coast LED.

The important thing to point out to students is the differenced and similarities between the red and green LEDs. Both LEDs are similar in that they are polarized with a positive and negative end. They are also similar in that they both generate "cool" light. They are different in that the cool light is of different colors (due to the materials used in their construction), and they are also different in how the different materials react to electricity – which leads to the collected data. Your numbers will not be the same but the relationships should hold.

1. Looking at Table 1 indicate to the students that both the red and green LEDs seem to draw about the same voltage, current and power, although the green LED has more internal resistance as compared with the red LED. This will become important shortly.

Single	**Volts**	**Amps**	**Ohms**	**Watts**
Red LED	2.020	0.022	91.81	0.044
Green LED	2.305	0.022	104.77	0.050

Table 1 – Red LED Compared with Green LED

2. With two LEDs in series the resistances add to each other like resistors in series. However, unlike resistors in series the internal LED resistances actually increase by more than double. This is because resistors are "passive" electrical devices and LEDs are "active" electrical devices meaning that the flow of electrons in an LED changes more actively when voltage is applied. Look at how much less power the green LED uses as compared with the red LED when wired in series.

2 in Series	**Volts**	**Amps**	**Ohms**	**Watts**
Red LEDs	3.791	0.013	291.61	0.049
Green LEDs	4.069	0.007	581.28	0.028

Table 2 – Red LEDs in Series Compared with Green LEDs in Series

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3. Finally, with LEDs in parallel the total resistance is less like resistors in parallel. But once again, the resistances do not drop to one-half; they only drop a fraction. The power for each of the LEDs in parallel is about the same.

2 in Parallel	**Volts**	**Amps**	**Ohms**	**Watts**
Red LEDs	1.840	0.023	80.00	0.042
Green LEDs	2.118	0.023	92.08	0.048

Table 3 – Red LEDs in Parallel Compared with Green LEDs in Parallel

4. You can conclude this part of the lesson by saying that LEDs in series appear to be the better choice for generating the most light with the least amount of power – especially if the LEDs are green in color.

TEACHER GUIDELINES AND TIPS

1. You are encouraged to repeat the lesson using more LEDs in series and parallel to see what happens.

2. Also, have the students mix the red and green colors and measure the results like above.

3. Have students place different colors of transparent plastic over regular incandescent lights like a regular flashlight to see how the overall light decreases. Indicate to them that this is yet another advantage of using LEDs, since LEDs glow as brightly in their respective colors as incandescent light does by itself. **Be careful NOT to use a regular 40, 60 or 100 watt blub for this example as the color plastic may melt or catch fire!**

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